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Pattern of Plant Species Diversity in Related to Physiographic Factors in Melah Gavan Protected Area, Iran

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Abstract: The aim was to study biodiversity of plant species including trees, shrubs and grasses in related to physiographic factors (aspect, elevation above sea level and slope percentage) in Melah Gavan protected area from northwestern Ilam province, Iran. The field data were collected using a number of 67 field plots in a systematic randomized design (each covering 20×20 m). The characters including tree and shrub species type, number and canopy coverage were recorded by measuring their small/large diameters in each plot. In order to record the herbaceous species, the Whitaker's snail plot method was applied and the minimum plot area 81 m^2 was determined. Based on the results, there are two tree species, one Shrub and 74 Grasses (belonging to 71 genus and 29 families) in the study area. The family Poaceae and the genus *Euphorbia* sp. form the most existing plants as well as *Therophytes* cover (51%) the most vegetative form in the area. The results obtained from multivariate Duncan test showed that the biodiversity is maximum in southern aspect and minimum in eastern aspect. Moreover, plant richness was the most in southern aspect while it was not significantly different in the other aspects. Investigation of biodiversity and richness amongst the altitude classes showed that the low altitudes (1400-1500 and 1500-1600 m ranges) have the most, while the upper altitudes (1800-1900 and 1900-2000 m ranges) have the least diversity. The ANOVA results also showed that the slope percentage had a significant effect on biodiversity and richness of plants. The results obtained from multivariate Duncan test showed that the biodiversity and richness are maximum in 0 - 25 slope percentage.

Key words: Biodiversity, environmental factors, Melah Gavan protected area, Zagros forest

INTRODUCTION

Maintenance, management and suitable utilization of plant coverage have required scientific recognition. The information resulted from vegetation can be useful to solve the ecological problems such as biological conservation and natural resources management and the future of an ecosystem trends can be forecasted using those information. In other words, vegetation can be useful to exhibit some ecological factors (e.g., microclimate, soil, light, physiographic etc.) which might be hard to measure directly (Daubenmire, 1976). Nowadays, numerous sustainable development plans are programmed to minimize the damages associated with biodiversity. Biodiversity and climate change have also been emphasized as two major environmental problems during recent years. In other words, the global environmental degradation has been severely occurred so that it has been introduced as one of the main environmental troubles worldwide. Studying vegetation and various environmental factors (e.g., physiographic, climate, soil, etc.), the communities stability and the factors correlation with the vegetation can be reached, which is crucial in terms of forest communities development and rehabilitation (Basiri, 2003). Moreover, optimized utilization of natural resources is somehow

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impossible without its comprehensive and scientific recognition. Thus, a balance between production and utilization can be achieved by studies on the ecological resources and environment. The geographical factors (e.g., altitude, latitude, aspect and slope) have an important role in plant species distribution by their effects on the soil moisture and chemical characteristics (Enright *et al*., 2005). Physiography can be referred as a given terrain relief which has a major influence on plant species diversity and their distribution (Barnes *et al*., 1998). Altitude is one of the limiting and effective factors on plant species growth and dispersion. One of the common effects caused by altitude variation is the occurrence of different vegetative forms and forest types (Tabatabaei and Ghasriani, 1992). Many researches have emphasized on the effects of altitude on vegetation dispersion, diversity and richness all over the world (Alessandro and Marcello, 2003). Aspect can also be effective on the species composition, diversity and richness (Nuzzo, 1996). Aspect can-mainly due to its effects on moisture contents of the slopes, variation in sunlight and wind blow-be effective on soil moisture, fertility and depth and thus on plants growth and dispersion. This is especially crucial in the areas associated with low moisture and rainfall levels (Christine and Mc Carthy, 2005). In addition, slope is another physiographic factor which can be effective on the plants dispersal, diversity, richness and growth, mainly because of its effects on soil drainage and depth (Boll *et al*., 2005). Enright *et al*. (2005) stated that physical factors (e.g., slope degree and being stony) are the most effective factors on plant dispersal and growth compared to the soil chemical content and human-induced factors, mainly due to their influence on water. In other word, many scientists have studied the biodiversity in relation to different physiographic factors separately or totally (Baker and Barens, 1998). In this regard, some study carried out in Iran (Saberyan, 2000) but like this research particular in Zagros region was very paucity. Owing to the importance of Zagros forests in terms of plant and animal species, genetic sources, understory rangelands, socio-economic problems etc, protection of the forest ecosystems and biodiversity is crucial in order to reach the sustainable development. Toward that, one of the important steps understands vegetation and the factors affecting the plants richness, diversity and dispersal. A few attempts have been made to study the above-mentioned issues in Zagros forests. The purpose of this study is to survey the species diversity, evenness, richness and investigate the physiographic factors (aspect, altitude and slope percentage) affecting diversity indices in the study area, so that a better assumption is made to effectively rehabilitate and utilize those resources.

MATERIALS AND METHODS

Study Area

The study was carried out in an area of approximately 160 ha in Melah Gavan protected area in Ilam province, Iran (Fig. 1). The altitude ranges from 1400-2000 m above sea level and the slope ranges from 5-85% within the area. The area has been enacted as a protected area by the National Department of Environment (NDE) in order to protect and rehabilitate the fauna and flora (due to the act No. 154) (Heydari, 2006).

The mean annual precipitation and temperature over the area are 540.27 mm and 18.20°C, respectively. The dry season in the area starts in the late April and lasts at the late September.

Methods

The field survey was conducted using a number of 67 field plots in a systematic- randomized design, each plot covering 20×20 m area. Tree and shrub species type, number and canopy coverage (measuring their small/large diameters) were recorded inside the plots. In order to record grass samples, the Whittaker's nested sampling plot method was used and the minimum area 81 m^2 was determined. In the intercept, the area and the species number for each plot were drawn toward X an Y axis, respectively Then, in the intersection point where the curve became horizontal, a vertical line was

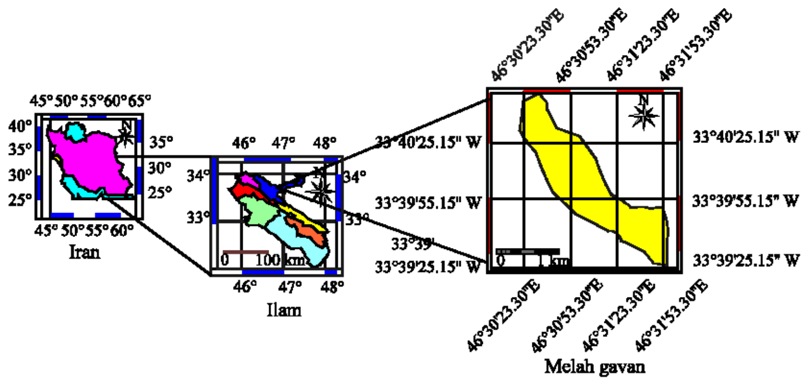

Fig. 1: Geographical location of the study area in Iran and Ilam Province

drawn toward the X-axis. In the present study, the mentioned minimum plot area was obtained to be 64 m^2. The plot area was considered 81 m^2 in order to increase precision. First, the species scientific name was recorded in each plot. Then, the species canopy coverage was estimated using Dumin criterion.

Data Analysis

In order to evaluate the plant diversity over the study area, some indices including Shannon-Wiener, Margalef richness and Pieloue's evenness indices were applied as following:

$$H' = -\sum_{i=1}^{s} p_i \mathrm{Ln} p_i$$

$$J' = \frac{H'}{H_{MAX}}$$

$$R_1 = \frac{S-1}{\mathrm{Ln}(N)}$$

where, H′ is Shannon-Wiener's diversity index, S is the total number of species (richness) and P_i is the proportion of individuals in the ith species ($P_i = n_i/N$, n_i is the number of individuals in the ith species and N is the total number of individuals) (Shannon and Weaver, 1949). Pielou's J′ is that $H'/H_{max} = H'/\log S$ and J′ is constrained between 0 and 1, with 1 representing a situation in which all species are equally abundant.

The altitude from sea level using altimeter, slope using sunto and aspect from top of the slope were recorded in each plot. The altitude was classified to 6 classes (from 1400-2000 m a. s. l.), slope was stratified into 4 major classes (0-25, 25-50, 50-75 and 75-100) and aspect was allocated to 4 classes (N, NE and E, S and SW and E). The normal distribution of the data in each environmental factor was tested using Kolmogorov-Smirnov test and the homogeneity of variances was checked using leven's test. Regarding to the normal distribution of the data, a one-way variance test was used to study the major differences among the classes. In order to record the grass species, the Whitaker's snail plot method was applied yielded in 81 m^2 of the minimum plot area.

RESULTS

The results showed that there are two tree species, one Shrub and 74 grasses (belonging to 71 genus and 29 families) within the study site. Poaceae and the genus *Euphorbia* sp. formed the most

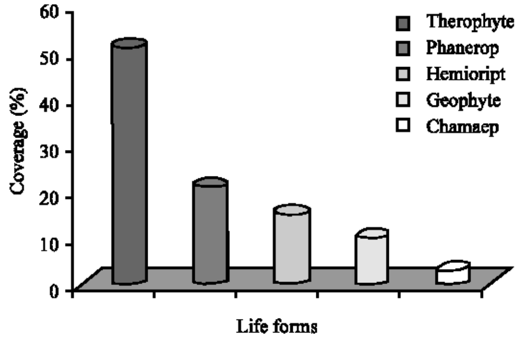

Fig. 2: Life forms classification using Raunkiaer's method

Table 1: Maximum, minimum and mean of biodiversity indices in study area

	Indices		
Statistical data	Margalef's richness	Shannon-wiener	Pieloue's evenness
Maximum	4.56	2.31	0.89
Minimum	1.50	1.31	0.61
Mean	3.01	1.48	0.69

Table 2: The results of ANOVA on altitude, aspect and slope factors

Variation source	df	F-values	p-values
Altitude			
Biodiversity	5	2.40	0.03*
Richness	5	3.00	0.02*
Evenness	5	2.60	0.2^{ns}
Aspect			
Biodiversity	3	3.50	0.04*
Richness	3	7.00	0.002**
Evenness	3	1.08	0.5ns
Slope			
Biodiversity	3	3.50	0.03*
Richness	3	6.60	0.002**
Evenness	3	1.10	0.4^{ns}

^{ns}: No significant; *: Significant (α<5%); **: Significant (α<1%)

abundance of the plant species. The results of life forms classification using Raunkiaer's method showed that Therophytes occupy the most life forms (51%) of the site (Barnes *et al.*, 1998) (Fig. 2). Shannon-Wiener index ranging from 1.31-2.31, Margalof index 1.5-4.56 and Pielou's eveness 0.61-0.89 (Table 1).

Biodiversity Result

The results of this study revealed that factors including altitude, aspect and slope have significant difference on species richness, diversity and evenness. In other words, results showed that elevation above sea level had a significant effect on diversity (p = 0.03) and richness (p = 0.02), so that lower elevation (1400-1500 and 1500-1600 m ranges) had higher value rather than upper elevation (1800-1900 and 1900-2000 m above sea level) in part of plant diversity and richness. Furthermore, aspect had a significant effect on biodiversity (p = 0.04) and richness (p = 0.002), so that, S and SW slopes had higher diversity index rather than other aspect. In addition, slope had a significant effect on diversity (p = 0.03) and richness (p = 0.002), region with low slope had high richness and diversity. Whereas there are no significantly effective for evenness (p = 0.4) (Table 2, Fig. 3, 4).

The results obtained from multivariate Duncan test showed that diversity is maximum in S and SW slopes, while it is minimum in E. Nevertheless, other aspects were not at significantly different

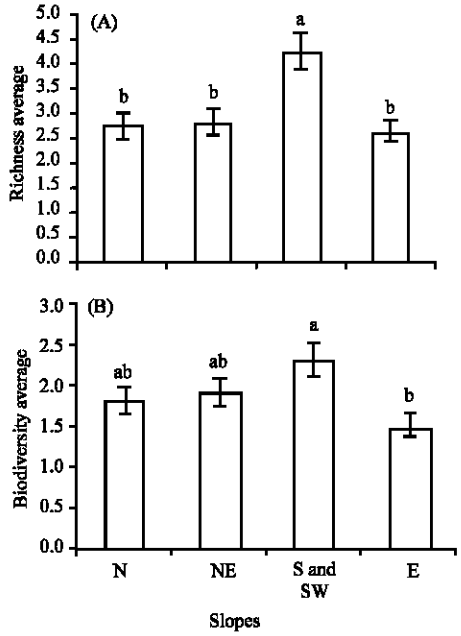

Fig. 3: The results of Duncan test for (A) plant diversity and (B) richness in different aspect (α<5%)

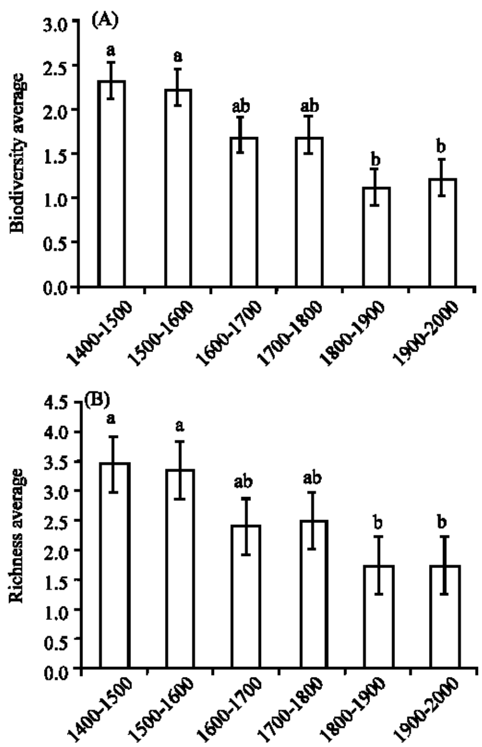

Fig. 4: The results of Duncan test for (A) plant diversity and (B) richness amongst the altitude ranges (α<5%)

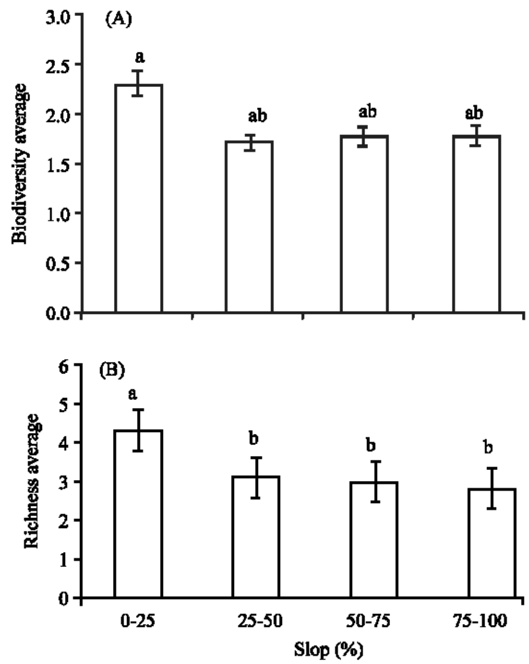

Fig. 5: The results of Duncan test for (A) plant diversity and (B) richness amongst the slope ranges (α<5%)

in terms of that. Richness was also maximum in S and SW, whereas other aspects were not significantly different (Fig. 3A, B). Investigating Diversity amongst the altitude ranges showed that the low altitudes (1400-1500 and 1500-1600 m) are associated with the maximum, while the high altitudes (1800-1900 and 1900-2000 m) contain the minimum rate of diversity. The other altitudes did not show a significant difference (Fig. 4A, B). Richness amongst the altitude ranges also same condition with diversity.

Survey slope percentage amongst the slope ranges showed that the low slope (0-25%) had the high diversity and richness. The other slopes were the same homogeneous group (Fig. 5A, B).

DISCUSSION

The present study also revealed that aspects have a significant effect on species diversity and richness. Our study also supports the results given by Basiri (2003) and Badano *et al*. (2005). In calcareous sites of Britain, the species distribution strongly correlated to slope and aspect, mainly because of its effects on the solar energy obtained by the terrain which results in 10-20% deficit of moisture content in southern slopes compared to the northern aspect (Perring, 1959).

Across the study site, the S and SW aspects had the highest value of plant diversity and richness. The reason can be the arid environment of those aspects which results in the lower tree cover density and thus increase the light level in the forest floor. Shmida and Wilson (1985) found out that the plant diversity is related to the edaphically heterogeneity (e.g., the existence of rugged surfaces) in semi- arid environment in USA, so that, the more rugged area would have more biodiversity than the other areas. Investigating the desert areas and its relation to the vegetation in Pakistan, it was revealed that there is a great difference in plant species composition in mountainous, plain, damp and beach areas. Physical factors such as slope, rocks are more important factors (compared to soil chemical content and human induces factors) to define the vegetation types dispersal and species richness. The study also admitted that the value of richness and diversity tends to be more in the arid climates compared to humid ones (Enright *et al*., 2005). In a study carried out in New York-USA, it was concluded that the difference existing in plant diversity between N and S aspects is depended on the difference in moisture content between the aspects (Marsh, 1991). Moustafa and Zayed (1996) investigated the effects of environmental factors on vegetation established on alluvial plains of Sina desert. They stated that the species richness is different toward the humidity difference. Also, humidity change is a mixture of changes related to altitude, slope, climatic drought and texture and nature of top soil, so that plant species diversity is higher in drier aspects than another aspect. Sebastia (2004) showed that the soil fertility is the main environmental factor in vegetation establishment. Moreover, topography has an indirect effect on plant community distribution. Because topography affects soil (e.g., slope, aspect and micro topography will affect soil drought and moisture).

Badanon *et al*. (2005) attributed the high richness and diversity of species in S aspects to the higher temperature and aridity of those aspects compared to the others. Based upon the results of this study, it was clarified that altitude has a significant effect on the species diversity and richness. Jazerehei and Ebrahimirastaghi (2003) also consider the altitude as a limiting factor in Zagros forests and highlight the importance of altitude in plants distribution pattern within those forests. Moreover, it has been pointed out in many studies that the altitude has a major influence on species diversity and richness (Petragilia and Tomaselli, 2003; Fu *et al*., 2004; Rikhari *et al*., 1991). The results also showed that the species diversity is higher in low altitudes as compared with the others. In addition, the lowest diversity has been shown to be in high altitudes. This also holds true for richness. Hegazy *et al*. (1998) had already confirmed the view that the highest plant diversity exists normally in the middle altitudes, highlighting the role of suitable temperature in those areas. In Nepal, Grytnes and Vetaas (2002) stated that the highest plant diversity exists in the middle altitudes and it reduces as the altitude increases. They also attributed the plant diversity reduction to the loss of temperature. In Siahkal Forests of Northern Iran, Fallah Chai and Marvie (2004) showed that the minimum value of diversity and richness can be found in the highest altitudes. In this study, slope had significant effect on richness and diversity and high richness and diversity and Survey slope percentage amongst the slope ranges showed that the low slope (0-25%) had the high diversity and richness. Slope percentage has been introduced as an effective factor on diversity and richness (Boll *et al*., 2005). Increase slope percentage has unfavorable effect on plant diversity because in intensive slope water drainage, washing soil and decrease fertility occur (Sohrabi, 2003). This was also concluded that the species *Quercus brantii* Lind (from trees) and *Bromus tectorum* (from herbaceous) have the most species value within the study site. Sohrabi (2003) have already mentioned those two species as the most abundant species over Zagros region.

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